

# COGNITIVE FEATURES FOR SENTENCE STRESS PATTERN DESCRIPTION

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**Abstract:** The paper proposes cognitive features for describing sentence stress patterns produced by emphasized and non-emphasized intonational contours of utterances. Cognitive features consist in hierarchies of binary cognitive structures described in terms of the functional categories of the cognitive model proposed in the paper. The cognitive perspective of the model transforms weak-strong “metrical” structures used by Ladd (2008), into binary structures with one nuclear element and two structural levels: CU\_argument-CU\_predicate CU\_emotional-CU\_rational element. A set of rules are presented, for nucleus identification in both emphasized and non-emphasized contours. Intonational contours analyzed in the paper correspond to some sentences also discussed in Ladd (2008). Cognitive analyses aim to assign different cognitive descriptions to different utterances even in the case of the same sentence when they produce different sentence stress patterns. We conclude that the prosody conveys non-linguistic meaning which must be understood at the cognitive or pre-linguistic level.

**Keywords:** sentence stress, prosody, cognitive model, predicate-argument, cognitive features

## 1. Introduction

The paper proposes a set of cognitive features for describing sentence stress patterns produced by emphasized and non-emphasized intonational contours of utterances. In the case of contours with high prominent pitch accent, two sentence stress cases are distinguished in the paper: (i) the case of sentence stress produced by emphasis, when emphasis and pitch accent “go hand in hand” (Ladd 2008: 256); (ii) the case where high pitch accent does not produce emphasis. In line with the latter case the paper proposes a discussion of English *wh*-questions (1) which has an ambiguous intonation contour, because in Ladd’s opinion, it has final stress on the group *robs banks* (broad focus case) but the prominent high pitch accent is on the last word, giving impression of emphasis and narrow focus in sentence-final position. The current paper argues why the contour related to the question (1) is non-emphasized and the last pitch accent does not produce emphasis.

(1) Why do you (rob banks)<sub>F</sub>?

On the contrary, the final pitch accent in the contour of sentence (2) presented in Ladd (2008: 260), generates emphasis on *diaries* that supports the narrow focus event at the linguistic level. The paper must clarify why a prominent pitch accent does not produce emphasis in (1), despite its high prominence, but the pitch accent on *diaries* in (2) produces emphasis even if it is not as prominent (e.g. regarding pitch range between its target tone and the previous one) as in the question case.

(2) My mother’s **diaries**<sub>F</sub>. (weak-strong; non-downstepped)

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Ladd (2008: 260) proposes weak-strong metrical structures for describing the sentence stress patterns of the sentence *My mother's diaries* in three pragmatic contexts. The “downstep” feature is added to the metrical structure in these descriptions as can be observed in (2)-(4). In (3), the “downstep” feature is replaced by the linguistic focus feature which justifies that *my mother's* is a strong element. In (2) and (4) there is no focus indication in the two descriptions but the “downstep” feature makes the difference between their two intonational variants having “non-downstepped” and “downstepped” values in (2) and (4), respectively.

- (3) **My mother's<sub>F</sub>** diaries. (strong-weak; focus on *mother*)  
 (4) My mother's **diaries<sub>F</sub>**. (weak-strong; downstepped)

Ladd (2008: 261-262) recognizes that in sentences with more than three words it is difficult to annotate the middle word/words at the phonological level in certain cases, and he proposes to describe them by metrical structures. One example is the contour of sentence (5) to which he associates a description based on right-branching and two-level metrical tree, where *a friend of mine* and *works* are weak constituents (annotated by *W* label) and *for NASA*, strong constituent (annotated by *S* label). The paper offers a cognitive basis for discussing “weak-strong” metrical structure of sentences in order to identify strong element of sentence with the auditory constituent that wins the competition with the other constituents of sentence during word evocation at the cortical level.

- (5) [A friend of mine<sup>W</sup> [works<sup>W</sup>/for NASA<sup>S</sup>]].

While Ladd was interested to describe sentence structures by involving only the prominence aspect of intonation (“weak-strong” structures), a large amount of effort was dedicated to describing the structure of sentences in terms of information structure (IS) categories (e.g. topic-focus, topic-comment) and to associating semantic functions of constituents with their intonational forms, as in e.g. Steedman (2000) and Wagner (2005). In these latter categories of approaches it was difficult to relate prosodic forms to semantic IS categories in order to give different semantic descriptions to different intonation contours of the same sentence. Thus, other linguistic devices were added.

Regarding the associations between semantic IS functions and intonational forms, Ladd (2008: 277) proposes “metrical” structure as “a better way to discuss universal feature of the expression of focus”, avoiding the problematic association of focus with certain types of phonological/phonetic features. He exemplifies this proposal by using the sentence (6) in two different pragmatic contexts. In Gussenhoven (1983)'s view, the two neutral intonational variants of sentence (6) correspond to the “contingency” reading, in (6a), and the “eventive” reading, in (6b). Ladd differentiates between the two sentence stress patterns by assigning the former variant to one description having one-level metrical structure, where focus is on the subject, and the latter variant, to another description having two separated prosodic phrases. In the first phrase the focus is on the subject *dogs* and in the second phrase, the verb *carried* bears focus.

- (6) a. [**Dogs<sub>F</sub>** must be carried].  
 b. [Dogs] [must be **carried<sub>F</sub>**].

The current paper proposes a key of intonational contour interpretation on which the sentence structure can be based. Ladd's "metrical" structure is closely related to syntactic and/or prosodic structure, and does not reflect the whole meaning of intonational contours. We consider prosodic structures have firstly pre-linguistic meaning related to cognitive relations which have been generated between sentence constituents during their evocation at the cortical level. The cognitive relations between the auditory objects of sentences also support the semantic events produced by their contexts.

The cognitive interpretation of intonational contours proposed in the paper is based on the following hypothesis: prosodic phrases of utterances convey the cognitive relations of the auditory objects corresponding to the words of the related sentences. It can be made in terms of Quilty-Dunn (2020)'s theory regarding perceptual object representations (PORs) where objects are merged into abstract cognitive relations between one pre-linguistic argument and one pre-linguistic predicate. This view transforms prosodic phrases with linguistic and prosodic constituents into relations between functional constituents that can be organized into hierarchical manner.

A relation on any level of hierarchy is treated as a single functional constituent at the next higher level where the relation is represented by its nuclear constituent. Nuclear element at the cognitive level corresponds to the "strong" part of phrase in Ladd's "metrical" view. Based on this mechanism of representing one group (a relation) by its local nuclear element in competition for the higher-level nuclear position, we can understand the difference between the focus realizations on English prepositional phrases with pronoun, such as *for him* in sentence (7), in two intonational variants presented in Ladd (2008: 266). We will show in the paper that the sensitive focus preposition *for* produces focus by emphasis on the pronoun *him* in variant (7a) and, on both words *for* and *him* taken as a unit in variant (7b). In the latter case, the preposition *for* is the nuclear element of the prepositional phrase and it represents the phrase at the global level where it competes with the constituent *I did it*.

- (7)    a.        I did it for **him**<sub>F</sub>.  
       b.        I did it (**for him**)<sub>F</sub>.

In the present paper "weak-strong" patterns of prosodic phrases are discussed in terms of non\_nuclear-nuclear element structure at the cognitive level and it is not based on the focus-non\_focus contrast at the linguistic level. The prominence of the nuclear constituent on any level of the utterance tree is a functional one because it represents the related phrase at the next higher level where it competes with other constituent for the higher level nuclear position. The cognitive model proposes rules for deducing nuclear element by involving only cognitive functions of constituents.

The cognitive model proposed in the current paper defines a set of the categories involved in the description of auditory object representations reflected by prosodic phrases and produced by the putative Information Packaging (IPk) mechanism of the speech generation module at the cortical level. The cognitive description of utterances is based on the identification of hierarchically organized relations and their nuclei. The model defines a set of rules that involve tonal and cognitive features of phrases in order to deduce their nuclear elements without involving syntactic/semantic reasons. The rules

were also used in Jitcă (2019), where they were correctly predicted the nuclear positions of the Romanian intonational contours analyzed in the respective paper. The predictions were in agreement with those claimed in Dascălu-Jinga (1998), Ladd (2008: 227-229), and Jitcă et al. (2015).

In the remainder of the paper, section 2 presents the IPk model, which has two structural levels and four functional categories. The fifth category of nucleus is related to the rules for nucleus identification within the IPk partition. In the section 3, the cognitive view was applied to the emphatic and non-emphatic contours of the English sentences selected from those discussed in Ladd (2008) and presented in section 1. Contours were described in terms of functional constituents and nuclear positions within hierarchically structured relations. The cognitive perspective gives a complete description of sentence stress patterns that improves Ladd's descriptions based on metrical structures.

## **2. The information packaging model**

This section summarizes the main aspects of the cognitive model we named IPk (information packaging) model. The model defines the functional categories assigned to constituents of cognitive relations and their overlapping structural levels. Cognitive relations, in the sense given by perceptual object representation theories, are reflected at the intonational contour level as information units structured by IPk partitions. Information units have two contrasting functional constituents that explain their name of contrast units (CU). The functional contrast involves constituents with contrasted cognitive functions. The contrast of auditory objects at the brain level is conveyed at the prosodic level by contrasted tonal features of constituents. They may be related to prosodic words, but they may also correspond to one of their parts (lower-level CUs) or to one of their compounds (higher-level CUs). In the cognitive model view, phonetic/phonological events of intonational contours are viewed as cognitive functional marks which also contain semantic IS meaning at the linguistic level.

The aim of utterance partitioning is to identify the CU hierarchy of utterances. CUs are structured by binary IPk partitions with two structural levels. In this paper, the two structural levels of IPk partitions are described at the cognitive level by using the functional categories of the IPk model.

### **2.1 Structural levels of IPk partitions**

The cognitive model defines IPk partitions with two structural levels conveyed by two overlapped tonal contrasts at the utterance level. They correspond, at the level of the brain, to the two levels of perceptual objects representations generated by the information packaging submodule of the cognitive system.

The pre-linguistic argument vs. the pre-linguistic predicate is one of the two functional contrasts of cognitive relations that is reflected by the two constituents of prosodic phrases at the utterance level. The model presented in von der Gabelentz (1869) and discussed by von Heusinger (2002), introduces an information structure of sentences/phrases that conveys a contrast between a psychological subject (PS), related to

“that about which the hearer should think”, and a psychological predicate (PP), related to “what he should think about it”. The PS-PP structure of phrases is exactly the pre-linguistic argument-predicate structure of cognitive relations. Hurford (2003) also considers the pre-linguistic predicate-argument structure as a fundamental structure used for representing objects at the cognitive system level. He considers the dorsal and ventral data streams as arguments for the existence of distinct predicate and argument functions of visual objects but the streams have to be related to the two information types: object information, about the features of objects (“what” or ventral stream), and structural information (“where” or dorsal stream) which encodes hierarchical structures of objects after their representation at the perception level. In the case of lesions of the dorsal stream, information about the features of visual objects from one image is preserved but their articulation within the hierarchical construction of their perceptual representation is altered. Thus, visual objects of the image can be recognized but they cannot be correctly localized.

In line with the POR’s theories and the above mentioned pre-linguistic models of information structure, the present paper proposes the predicate-argument structure as the first structural level of IPk partitions because cognitive auditory object representations are reflected by prosodic phrases at the utterance level. The predicate object of the cognitive relation corresponds at CU level to the CU\_predicate constituent that is always marked by the lower target tone of the phrase. The argument object of the relation corresponds to the CU\_argument constituent of CU that is marked by the higher target tone of the phrase. The target tone is the tone during the accented syllable (or a part of it) of the respective constituent. The CU prefix suggests that the argument/predicate functions are cognitive functions of CU constituents.

We hypothesize that the tonal variations during the CU\_predicate and CU\_argument constituents of one CU correspond at the neural level to the variations of activation levels of the neurons which evoke the corresponding auditory objects merged into a relation by a delta wave rhythm. Delta wave rhythm has the capability to modulate the firing level of the neurons that integrate auditory objects by relating them to its different phases (see Oblesser et al. 2019 about delta wave phases).

The second structural level of perceptual object representations gives representational content to emotional and attentional events. Oliver-Skuse (2016) based on perceptual theories of representing emotions, that draw an analogy between perceptions and emotions, claims that emotions should be represented in the same manner as perceptions, even if emotions have not their own “proper objects” and the perceptual objects are picked out from the cognitive basis. Oliver-Skuse (2016: 72) presents “the two features of emotions – one of being directed at an object and another one of being subject to an accuracy condition, as sufficient for emotions having representational contents” and claims that “an account of emotional representation involves showing how emotions get to be about their proper objects and also showing how the emotion becomes subject to an evaluative appropriateness condition”. Dolcos et al. (2020) are interested in emotion – attention interaction and how this interaction is involved in different cognitive processes, perception and memory being a few of them. It is stated that “the past two decades have seen an exponential increase in the research investigating the effects of affective information on working memory performance” (Dolcos et al. 2020: 24). The cognitive

model presented in the current paper shows how affective information can be added to the objects within the perceptual object representation at the cognitive level.

In line with this view, the present model defines the second level of perceptual object representations in terms of CU\_emotional element and CU\_attentional element functional categories. The CU\_emotional element of IPk partitions is usually marked by longer duration and slow pitch variations, whereas the CU\_attentional element may be contrastively marked by an abrupt pitch movement. Another mark for CU\_attentional element may be a constant tonal level with small pitch range variations during its prosodic word, the related CU\_emotional element showing an upstepping or downstepping tendency.

The overlapping of the two structural levels of relations is due, at neurobiological level, to the two types of acoustic features of delta wave phases (levels and timing) and, at the intonational contour level, to the two dimensions of pitch variation: tonal target levels and the shape or slope of the pitch excursion (temporal features). The two structural levels, the CU\_predicate-CU\_argument and the CU\_emotional element-CU\_attentional element, proposed by the IPk model, constitute a basis for the utterance partitioning description. The constituents of IPk partitions may be treated as cognitive functional elements in direct relationship to their intonational marks. Semantic IS events can be discussed in relationship to the cognitive constituents of utterances. In the current paper, most of the comments on IPk partition descriptions refer to the first structural level, because it explains the realization of another important IPk event at CU level, related to the category of nucleus.

## 2.2 Hierarchical organization of IPk partitions

At IPk level, the nuclear accent of CU corresponds to the functional element which represents the respective unit to the higher-level CU. We say that it bears the functional prominence within lower-level CU. Thus, a CU becomes a functional element of the higher-level partition, with the same IPk functions as its nuclear element. We suggest that a competition exists between constituents, at the neurobiological level, between the neurons that evoke the auditory items structured into relations. One of the neurons (of the nuclear item) wins against other neurons (of the non-nuclear item), being influenced by different brain rhythms synchronized with the respective auditory data items. After the nuclear element wins the competition, the non-nuclear element is discarded from the high-gamma activity leading to an exclusion from the competition for the higher-level nuclear positions. This may be an explanation of the strong constraint about the neuronal implementation of the merge operation formulated in Nelson (2017: E3677): “each merge is reflected by a sudden decrease of high gamma activity in language areas”. We give a neurobiological basis to the nuclear element of phrases; it corresponds to the object that is not discarded from the high gamma neural activity and represents the previously merged relation competing for the higher-level nuclear position.

Two separated sets of rules for nucleus identification are formulated in relation to the two types of contours of IPk partitions: emphasized and non-emphasized. In the former case emphasis position may be identified in contours with descending phrase-final contour. We formulate the nucleus identification rule NIR\_E in (8):

- (8) NIR\_E: Within IPk partitions with descending phrase-final contour, the CU\_argument element with the highest and prominent target tone, bears emphasis and nuclear function.

In the case of IPk partitions with non-emphasized contour two rules are formulated related to the two cases involving the tonal spaces of the two constituents: with separated and overlapping tonal spaces. In the former case, the constituent with high target tone prosodically subordinates the lower target tone element and becomes nuclear. In the latter case, the low prominence is significant and the element with the lowest target tone bears the nuclear function. The Nucleus Identification Rules, NIR\_C and NIR\_S, summarize the cognitive basis of nucleus identification in the two cases: partition with coordinated elements (9) and partition with a subordinated element (10):

- (9) NIR\_C: Within IPk partitions with coordinated elements and non-emphasized contour, the CU\_predicate element bears the nuclear function, being related to the low functional prominence produced by the lowest target tone.
- (10) NIR\_S: Within IPk partitions with a subordinated element and non-emphasized contour, the CU\_argument element bears the nuclear function, being related to the high functional prominence produced by the highest target tone.

### 2.3 Description system of IPk partitions

According to the here presented IPk model, any simple or complex utterance may be decomposed into a hierarchy of CUs, each of them having its own partition. P and A labels were introduced for annotating CU\_Predicate and CU\_Argument constituents, and E and T labels for annotating CU\_Emotional and CU\_aTentional elements within IPk partition descriptions. In the proposed description system, two labels are used for annotating an element of partition, once it has functions at the two structural levels. Labels are linked by “+” and enclosed between round parentheses.

The IPk partition description is a sequence of two pairs of round parentheses separated by slash, corresponding to the two CU constituents. In (11a-d), all four possible IPk partition variants for a CU are presented:

- (11) a. (A+E)/(P+T)  
 b. (A+T)/(P+E)  
 c. (P+E)/(A+T)  
 d. (P+T)/(A+E)

The description of a CU with lower-level CU(s) as constituents includes the description of lower-level IPk partitions between brackets and places a functional label in the index position after the right bracket. In (12), a generic description of the two nested IPk partitions of a sentence with SVO (Subject-Verb-Object) structure is presented. The lower-level CU with generic NF functional label is paired with the first functional constituent (the subject), having a contrasted function (F label) at the global IPk

partition level. The F generic label may have one of the following values: (A+E), (P+T), (A+T), (P+E).

$$(12) \quad \{(F)^{\text{Subject}}/\{(F)^{\text{Verb}}/(\text{NF})^{\text{Object}}\}_{\text{NF}}\}$$

The NF functional label of the embedded CU is due to the projection of the NF generic function at the whole embedded CU level, being due to the nuclear function of the NF constituent. The annotation system presented in this paragraph is used in the paper at describing the sentences discussed in section 1 at the cognitive level.

### 3. Cognitive descriptions of some emphasized/non-emphasized contours

Intonational contours discussed in this section correspond to the sentences presented in the first section in Ladd's "metrical" view. The cognitive analysis of the sentences aims to demonstrate that each sentence can be assigned to one cognitive description and the same sentence with different sentence stress patterns has different cognitive descriptions. We based our analysis on the basic idea that the entire prosody conveys non-linguistic (pre-linguistic) meaning, which must be understood at the cognitive level.

In 3.1 a comparative analysis of the contours that generate the three sentence stress patterns of the sentence *My mother's diaries* are presented. Three examples of utterances with two-level hierarchies are described in section 3.2 and cognitive descriptions are then compared with Ladd's descriptions based on hierarchical metrical structures. In section 3.3 the two cases of prepositional phrases with preposition *for* are presented in order to explain the two focus cases: with emphasis on pronoun and, with emphasis on the preposition.

#### 3.1 Three sentence stress patterns of the sentence *My mother's diaries*

The section presents three cognitive descriptions related to the three utterances of the sentence presented in (2)-(4). The first utterance corresponds to the contour in Figure 1. The peak in the contour produces the nuclear function of the first constituent *my mother's* that has a separated high tonal space in respect to that of the last constituent *diaries*. Two labels are applied to the former element: A+T label signifies that it is a CU\_argument, and N label suggests that it is the nuclear element of the partition as it is presented in (13). P+E label applied to the latter constituent signifies its CU\_predicate function. T and E labels annotate *my mother's* as CU\_attentional element (falling-rising pitch movement) and *diaries* as CU\_emotional element (slow downstepping movement). The nuclear function of the first constituent is deduced by applying NIR\_S rule that identifies the nuclear position with the high tonal space constituent.

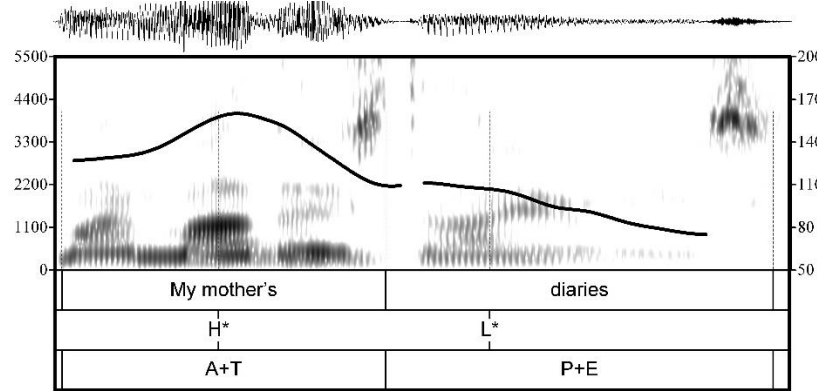


Figure 1. F0 contour and spectrogram of the statement *My mother's<sub>F</sub> diaries*.

(13) **My mother's<sub>N</sub><sup>A+T</sup>/diaries<sub>P+E</sub>**.

Emphasis occurs within contours with descending phrase-final contours where one of pitch accents has the highest target tone and rising-falling pitch movement during the vocalic part of the related accented syllable. It is the case of the contour presented in Figure 2 where emphasis is produced by the peak with the highest target tone on the accented syllable of the word *diaries* leading to its CU\_argument and nuclear functions. The last constituent is in contrast with the first constituent *My mother's* which is the CU\_predicate of the phrase (!H\* signifies a high pitch accent with lower target tone than the other constituent with high pitch accent). The contour is an emphasized one and the CU\_argument element bears the nuclear function (NIR\_E rule) at the cognitive level and the narrow focus function at the linguistic level, as it is described in (14). The emphasized and focus element in both analyzed contours is of CU\_attentional element type having the abrupt falling pitch movement.

(14) **My mother's<sub>P+E</sub>/diaries<sub>N</sub><sup>A+T</sup>**.

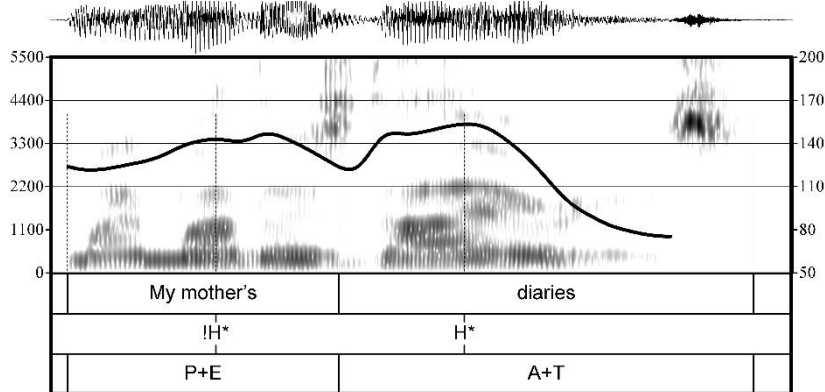


Figure 2. F0 contour and spectrogram of the statement *My mother's<sub>F</sub> diaries<sub>F</sub>*.

The contour in Figure 3 shows a non-emphasized contour because the peak on *my mother's* does not synchronize its maximum height with the first accented syllable. The two constituents have overlapping tonal spaces and the last one has CU\_predicate function (lower target tone). The two conditions give nuclear function to the latter one (NIR\_C rule) which also bears the “focus” function at the linguistic level in the broad focus context. In Ladd’s view *diaries* is the “strong” element in both cases of contours in Figures 2-3 and the “downstep” feature makes the difference between the two contours feature by its non-downstepped vs. downstepped values, as it is presented in (2) and (4). In the cognitive perspective, the difference between contours in Figure 2 and Figure 3 is a structural one, the former one having CU\_predicate-CU\_argument structure and the latter contour having CU\_argument-CU\_predicate structure, as it is described in (14) and (15).

(15) My mother’s <sup>A+T</sup>/**diaries**<sup>P+E</sup><sub>N</sub>.

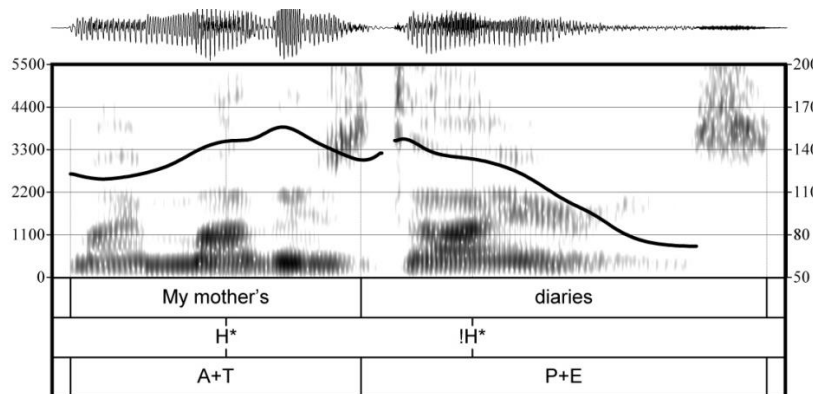


Figure 3. F0 contour and spectrogram of the statement *My mother's diaries*<sub>F</sub>.

(13)–(15) summarize the cognitive correlates of metrical and phonetic features used by Ladd for describing the three contours. The weak-strong metrical structure corresponds to non\_nuclear-nuclear element structure. The “downstepped” value of the “downstep” feature is translated by the CU\_argument-CU\_predicate structure and the “non-downstepped” value, by the CU\_predicate-CU\_argument structure. The “focus” element in the broad focus case is the global CU\_predicate and nuclear element. We conclude that the “strong” element in the sentence-final position corresponds to the CU\_argument in the narrow focus case, and the CU\_predicate in the broad focus case.

### 3.2 Sentence stress patterns with two-level hierarchy

The advantage of the cognitive features can be highlighted by analyzing contours with more than two constituents that are exemplified by the contour of the broad focus statement *A friend of mine works for NASA*, presented in Figure 4.

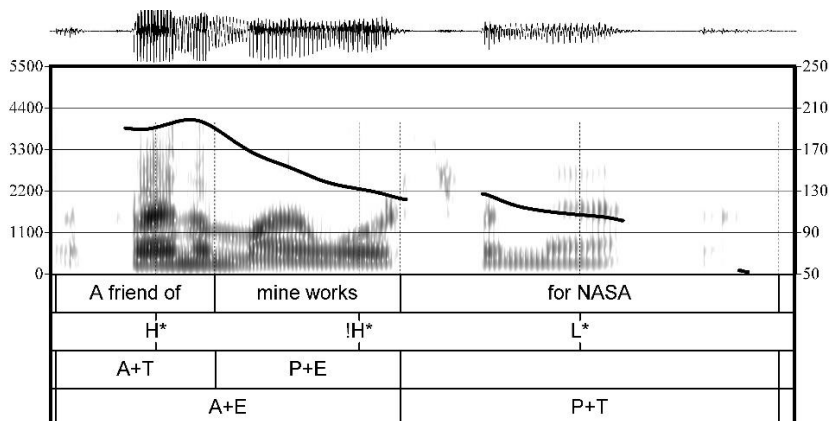


Figure 4. F0 contour and spectrogram of the statement  
*A friend of mine works for NASA* ‘F’.

The description by using the “metrical” structure proposed by Ladd is presented in the current paper in (5) where we can see that the first two constituents are taken as “weak” elements and the last one as the “strong” element. In his interpretation the lower-level partition corresponds to the verbal phrase and the global partition has the nominal group as the first constituent paired with the verbal phrase as the second element.

In Figure 4 we can observe that the nominal group *A friend of mine* is grouped with the verb *works* within the lower-level partition where the former element has the CU\_argument function and the latter one, the CU\_predicate function. The verb *works* has the local nuclear function (NIR\_C rule) and competes with *NASA* for the global nuclear function at the next higher level. *NASA* is the global nuclear element having the lowest tonal target (the global CU\_predicate function). In the cognitive perspective, the utterance has one “weak” constituent (the CU\_argument element) and two “strong” constituents which correspond to the CU\_predicate elements of the two nested cognitive relations described in (16):

$$(16) \quad [[A \text{ friend of mine}^{A+T}/\text{works}^{P+E}]_{A+E}/\text{for NASA}^{P+T}]_{P+T}.$$

The structural information at the cognitive level (the suprasegmental information of the utterance) is stored in the working memory together with the phonetic information (the segmental information of the utterance). Contrast between functional constituents of relations has to be observed in cognitive relations, at both structural levels: CU\_argument-CU\_predicate and CU\_attentional-CU\_emotional elements. Another test for the cognitive model consists in describing the different intonational variants of the same sentence with more than two constituents. We select for this test the sentence *Dogs must be carried* also described by Ladd, as it is presented in (6a) and (6b). The description of the first variant groups all constituents in one intonational phrase and the second variant separates the subject *dogs* and the verbal phrase *must be carried* in two prosodic phrases. The contours of the two variants are illustrated in Figure 5 and Figure 6.

In the case of the contour in Figure 5 the subject and the first part of the predicate *must be* are merged within the lower-level partition and their group is paired with the last verb *carried* at the global level. The contour of the lower-level partition has small pitch range variations at an intermediate tonal level, a higher target tone of the noun (CU\_argument) and a lower target tone of the verb *must be* (CU\_predicate). The latter bears the local nuclear function (NIR\_C rule).

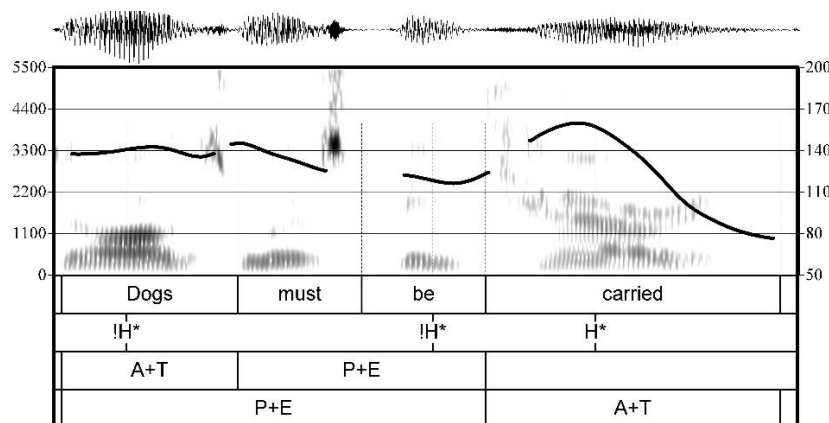


Figure 5. F0 contour and spectrogram of the statement *Dogs must be carried*<sub>F</sub>.

The global partition has an emphasized contour due to the emphasis on the last constituent, leading to its nuclear function at the cognitive level (NIR\_E rule) and its focus function at the semantic level. The contour is described in (17) by two nested IPk partitions where the local and global nuclear elements are annotated by n and N, respectively. In this case the utterance is structured by relating one prominent CU\_argument in the sentence-final position with a group which has the CU\_predicate function given by the local nuclear element of the modal and auxiliary verbs. The focus position is the same as in Ladd's description but the cognitive structure in (17) differs from that in (6a).

$$(17) \quad [[\text{Dogs}^{A+T} / \text{must be}_n^{P+E}]_{P+E} / \text{carried}_N^{A+T}]_{A+T}.$$

The utterance with the contour in Figure 6 is based on a cognitive relation between one prominent CU\_argument (the subject) in the sentence-initial position, and the predicate *must be carried* as the global CU\_predicate constituent. This cognitive relation at the global level corresponds to Ladd's "metrical" structure description, with two separated phrases, presented in (6b). In the cognitive view, the two parts of the verbal phrase *must be* and *carried* are merged within by the lower-level partition. The contour of the lower-level partition is a non-emphasized one where the last constituent *carried* bears the nuclear function because it has the lower target tone of the contour (CU\_predicate) and the two constituents have overlapping tonal spaces (NIR\_C rule).

The cognitive description of the contour in Figure 6 is presented in (18) where the local nuclear function of the last constituent is annotated by *n*. The global partition has a non-emphasized contour because the subject does not bear emphasis (the last descending part of the peak is not voiced) but it carries the nuclear function due to its CU\_argument function and the separated tonal spaces of the constituents (NIR\_S rule). It subordinates the last group of the predicate and bears the contrastive topic function at the linguistic level. Its global nuclear function is annotated by *N* in (18).

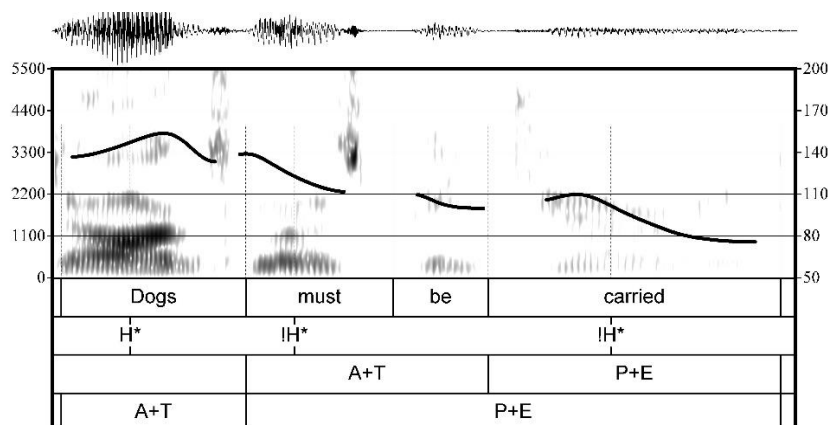


Figure 6. F0 contour and spectrogram of the statement  $(Dogs_F)_T$  *must be carried\_F*.

- (18)  $[Dogs_N^{A+T} / [must\ be^{A+T} / carried_n^{P+E}]_{P+E}]_{A+T}$ .

Krifka & Musan (2012) annotate contrastive topic at the linguistic level by “focus within topic...indicating the presence of alternatives, in this case, alternative topics. Focus is marked by (rising) accent, but it is not the main accent of the sentence, which is on the constituent of the comment”. At the cognitive level we can characterize the contrastive topic element as a CU\_argument bearing the global nuclear function (N label) and there is no need to annotate it by “focus within topic” because the topic and focus are the contrasted categories at the semantic level and it makes no sense to apply them on the same constituent. The real or main focus constituent is in the comment part of contrastive topic statements where it bears local nuclear function, as is the case of the verb *carried* in (18).

### 3.3 Sentence stress patterns given by contours with final high prominence

In section 3.1 we have discussed the contour in Figure 2 with high acoustical prominence produced by emphasis on the last constituent that yields its focus function. In the current section we present two contours that support two types of sentence stress patterns of one sentence with focus within the prepositional phrase with the pronoun. They correspond to the two variants (7a) and (7b) of the sentence *I did it for him* discussed in (Ladd 2008: 266). Focus is elicited by the focus-sensitive preposition *for*

which generates emphasis either on the pronoun *him* or on the preposition *for*. Figure 7 and Figure 8 illustrate both intonational variants of the sentence.

In Figure 7 the first constituent *I did it*, has CU\_argument function having high tonal target as it is described in (19). It cannot be directly paired with the emphasized pronoun *him* which is also a CU\_argument element of the utterance which bears the high prominence. That explains why an element with lower target tone (the CU\_predicate) is generated during the preposition *for* and the first part of the pronoun *him* and, in order to produce a lower-level partition which connects the first CU\_argument with the CU\_predicate. The lower target tone constituent is annotated by *for hi-* at the text level. Thus, the contour is described in (19) by a two-level hierarchy of IPk partitions where the local nucleus is on the CU\_predicate (NIR\_C rule).

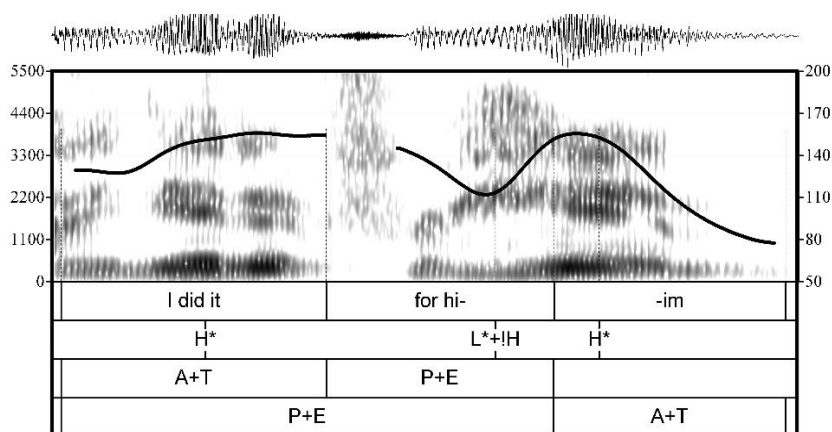


Figure 7. F0 contour and spectrogram of the statement *I did it for him<sub>F</sub>*.

- (19) [[I did it <sup>A+T</sup>/**for hi-** <sup>N<sup>P+E</sup></sup>]<sub>P+E</sub> /-im <sup>A+T</sup>]<sub>P+E</sub>.

The group and the first part of the constituent *him* and the constituent of the subject and the verb *I did it* are merged within a lower-level partition and their group is paired with the last part of the pronoun within the higher-level partition. At the global level, the nucleus is produced on the first part of the pronoun (*for hi-*) with the CU\_predicate function because the target tone of the second part does not exceed the level of the previous target tone and thus, it does not produce emphasis (NIR\_C rule).

In Figure 8 the contour of the second intonational variant of the sentence *I did it for him* shows that the sensitive-focus preposition subordinates the pronoun and both of them count as a single focus unit. This sentence stress variant is useful in a discourse when the pronoun is related to an already mentioned referent which is not relevant at the respective moment of discourse. The verbal phrase *I did it* is the CU\_predicate at the global level having lower target tone annotated by !H\* label. The CU\_argument element is the group of the words *for* and *him* where the former element is the CU\_argument at the local and global levels. The pronoun is the local CU\_predicate element at the prepositional phrase level, as it is described in (20).

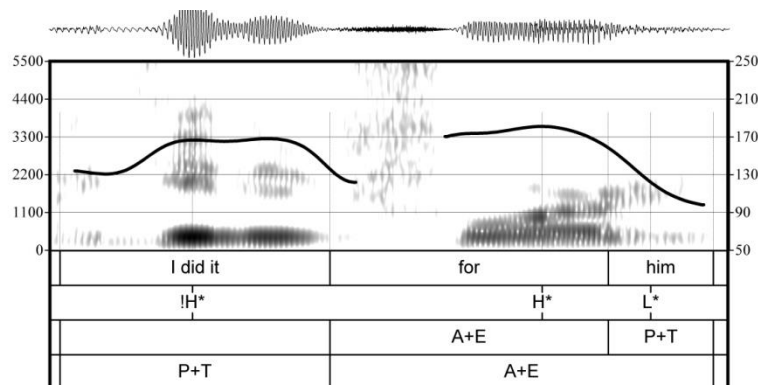


Figure 8. F0 contour and spectrogram of the statement *I did it (for<sub>E</sub> him)<sub>F</sub>*.

$$(20) \quad [I \text{ did it } ^{P+T} / [\text{for } ^{A+E} / \text{him } ^{P+T}]_{A+E}]_{A+E}.$$

The preposition *for* bears emphasis because during the vowel /o/ the F0 contour has pitch variations close to the top level of the tonal space. The preposition *for* has the local nuclear function (NIR\_S) because it subordinates the pronoun *him*. Its CU\_argument function is projected to the whole group which becomes the global CU\_argument constituent of the global partition. The group *for him* bears emphasis because the peak with the highest target tone in the contour spans the two words. The emphasis of the prepositional phrase gives it the global CU\_argument and nuclear functions which support its focus function at the linguistic level.

The contour in Figure 7 conveys a cognitive relation where the prepositional phrase *for him* is assigned as a pre-linguistic predicate to the verbal phrase *I did it*, while the cognitive relation corresponding to the contour in Figure 8 applies the pre-linguistic predicate *I did it* to the pre-linguistic argument *for him*.

Now we propose to compare the contour in Figure 8 with another contour with final high acoustical prominence of the interrogation (1) that is illustrated in Figure 9. The salient difference between them is the tendency of the contour in Figure 9 of holding low levels before acoustical prominence in comparison with the contour in Figure 8 that has segments with relative high tones under the level reached by the peak of emphasis. The tendency of low tones followed by the final high prominence, in the former case, leads us to the conclusion that the contour in Figure 9 has an ascending phrase-final contour, which is proper for interrogatives, while that in Figure 8 has a descending type which is proper for statements. The ascending/descending tendency feature of contours is the objective criterion for the last prominence interpretation as emphasis or not.

The contour in Figure 9 has to be interpreted as a contour with ascending phrase-final contour and a low boundary tone. Its nuclear element has to be thought in relation to a *negative* prominence marked by the lowest target tone. The negative prominence position has to be decided at the local partition level between the *wh*-word and the predicate. The former begins the small peak at lower tonal levels than that reached during the verb *rob* and the *wh*-word is the global CU\_predicate and the nuclear element of the information-seeking *wh*-question. The whole group *Why do you rob* is the

CU\_predicate constituent at global level. Its function is in contrast with the last constituent *banks* which is the global CU\_argument constituent. The two-level hierarchy is described in (21) where the *wh*-word is annotated as nuclear, by *N* label.

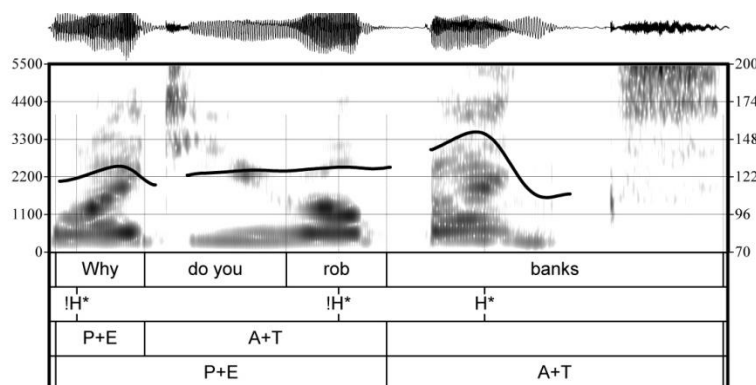


Figure 9. F0 contour and spectrogram of the information-seeking *wh*-question  
*Why do you rob banks?*

- (21) [Why<sub>N</sub><sup>P+E</sup> /do you rob<sup>A+T</sup>]<sub>P+E</sub> / banks<sup>A+T</sup>?

The last pitch accent gives an impression of emphasis due to its large rising pitch movement reaching the top level during the vowel part of the word *banks*, but an emphasis needs further to show a falling pitch movement with a significant level of energy during the vowel part of the syllable. In the case of the contour in Figure 9 the last falling pitch movement unfolds during the voiced consonant /n/.

We conclude that in light of the cognitive model both low and high tones may be involved in marking nuclear elements. A correct decision about high acoustical prominences will lead to a correct interpretation of contours as belonging to emphasized or non-emphasized types and then to a correct selection of the nucleus identification rule: NIR\_E or NIR\_C/NIR\_S, respectively.

#### 4. Conclusions

The present paper proposes an information-structure (IS) model for describing the cognitive meaning of intonational contours and the sentence stress pattern of the respective sentences. Cognitive features are discussed in terms of functional categories and the structures realized at the prosodic phrase level. In Ladd's view, the contrast within phrases has linguistic meaning conveyed by phonetic/phonological pitch features but in the present IS model view it has pre-linguistic (cognitive) meaning. Features used by Ladd in sentence stress patterns are the weak-strong metrical structure and the "downstep" feature. The cognitive perspective transforms weak-strong "metrical" structures into non-nuclear – nuclear structures and the "downstep" feature with the downstepped/non-downstepped values, into CU\_argument-CU\_predicate or

CU\_ predicate-CU\_argument structures of binary phrases. A set of rules are also proposed for nucleus identification in both emphasized and non-emphasized contours.

The binary IPk structures and the rules for nucleus identification create a solid ground for utterance partitioning into IPk partition hierarchies. The contrast within phrases is not only a weak-strong contrast, but it is firstly a functional one at the cognitive level. Before the weak-strong contrast, the structural patterns of phrases must be identified in terms of CU constituent categories.

In Ladd's view emphasis is the paralinguistic device that differentiates the sentence stress pattern that produces narrow focus on the last word, from the pattern that generates nucleus on the last word in the broad focus context. In the cognitive view, emphasis marks the global CU\_argument constituent with the highest target tone in phrase. The emphasized constituent has acoustical prominence (longer duration near the top level) which generates its nuclear function at the cognitive level. We must use the NIR\_E rule for nucleus identification and not the NIR\_C or NIR\_S rules that operate in phrases with non-emphasized contours.

Furthermore, the paper answers the question formulated in section 1 regarding the constituents with final high acoustical prominence that do not bear emphasis (Figure 9), by explaining that high prominences can generate emphasis only if the related pitch accents show a falling pitch movement with a significant level of energy during the vowel part of the syllable. If the high pitch accent does not produce emphasis, the low prominence marks the nuclear constituent of contour and the NIR\_C rule operates in order to identify the respective nuclear position. The high prominence which does not produce emphasis, marks the respective constituent as a global CU\_argument in contrast with the nuclear element which is the global CU\_predicate of the utterance.

We conclude that the features that describe sentence stress patterns have cognitive meaning and they must be translated in terms of the cognitive categories of the model presented in section 2. We propose these categories as cognitive primitives invoked by Poeppel (2012) for describing utterances, at the linguistic/speech level, in terms of their structures and functional elements that can be parallelized with structures and functional elements at the neurobiological level.

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